



Development of an Automated Plant-watering System Using Soil Moisture Sensors in a
Greenhouse Plantation for Palm Plants

A Thesis Proposal
Presented to the Faculty of the
Department of Electronics and Communications Engineering
Gokongwei College of Engineering
De La Salle University

In Partial Fulfillment of the
Requirements for the Degree of
Bachelor of Science in Computer Engineering

by
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May, 2016



De La Salle University

ORAL DEFENSE RECOMMENDATION SHEET

This thesis proposal, entitled **Development of an Automated Plant-watering System Using Soil Moisture Sensors in a Greenhouse Plantation for Palm Plants**, prepared and submitted by thesis group, ESG-04, composed of:

ABE, Paul Vince A.
MIRIDA, Joanna Katherine U.
AMADO, Dan Paulo E.

in partial fulfillment of the requirements for the degree of **Bachelor of Science in Computer Engineering (BS-CPE)** has been examined and is recommended for acceptance and approval for **ORAL DEFENSE**.

Dr. Francisco D. Baltasar
Adviser

May 30, 2016



De La Salle University

THESIS PROPOSAL APPROVAL SHEET

This thesis proposal entitled **Development of an Automated Plant-watering System Using Soil Moisture Sensors in a Greenhouse Plantation for Palm Plants**, prepared and submitted by:

ABE, Paul Vince A.
MIRIDA, Joanna Katherine U.
AMADO, Dan Paulo E.

with group number ESG-04 in partial fulfillment of the requirements for the degree of **Bachelor of Science in Computer Engineering (BS-CPE)** has been examined and is recommended for acceptance and approval.

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Dr. Amado Z. Hernandez
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Date: May 30, 2016



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ACKNOWLEDGMENT

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Write this prior to hard binding if you have submitted all requirements and are told by your adviser that you have passed.



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ABSTRACT

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Keep your abstract short by giving the gist/nutshell of your thesis proposal.

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Index Terms—PIC16F877A, soil moisture, greenhouse, automation.



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ABBREVIATIONS

148	AC	Alternating Current.....	30
149	CSS	Cascading Style Sheet	30
150	HTML	Hyper-text Markup Language	30
151	XML	eXtensible Markup Language	30



NOTATION

153	$ \mathcal{S} $	the number of elements in the set \mathcal{S}	32
154	\emptyset	the set with no elements	32
155	$h(t)$	impulse response	22
156	\mathcal{S}	a collection of distinct objects	32
157	\mathcal{U}	the set containing everything	32
158	$x(t)$	input signal represented in the time domain	22
159	$y(t)$	output signal represented in the time domain	22

160 Throughout this thesis proposal, mathematical notations conform to ISO 80000-2 standard,
161 e.g. variable names are printed in italics, the only exception being acronyms like e.g. SNR,
162 which are printed in regular font. Constants are also set in regular font like j . Functions are
163 also set in regular font, e.g. in $\sin(\cdot)$. Commonly used notations are t , f , $j = \sqrt{-1}$, n and
164 $\exp(\cdot)$, which refer to the time variable, frequency variable, imaginary unit, n th variable,
165 and exponential function, respectively.



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GLOSSARY

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matrix a concise and useful way of uniquely representing and working with linear transformations; a rectangular table of elements 32



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INTRODUCTION

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1.1 Background of the Study

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1.2 Prior Studies

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1.4 Objectives

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1.4.1 General Objective(s)

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1.4.2 Specific Objectives

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1.5 Significance of the Study

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1.6 Assumptions, Scope and Delimitations

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1.7 Description and Methodology

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1.8 Overview

Provide here a brief summary and what the reader should expect from each succeeding chapter. Show how each chapter are connected with each other.



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Chapter 2

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LITERATURE REVIEW

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308 Cite and summarize here relevant and significant literature (dissertations, theses, jour-
 309 nals, patents, notable conference papers) to prove that no one has done your work yet.

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2.1 Summary



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Appendix A ANSWERS TO QUESTIONS TO THIS THESIS PROPOSAL

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A1 How important is the problem to practice?

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 403 tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue
 404 a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris.
 405 Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit
 406 amet ipsum. Nunc quis urna dictum turpis accumsan semper.

407

A2 How will you know if the solution/s that you will achieve would be better than existing ones?

408

409 Lorem ipsum dolor sit amet, consectetur adipiscing elit. Etiam lobortis facilisis sem.
 410 Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec
 411 ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus
 412 placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor.
 413 Praesent in sapien. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Duis fringilla
 414 tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue
 415 a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris.
 416 Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit
 417 amet ipsum. Nunc quis urna dictum turpis accumsan semper.

418

A2.1 How will you measure the improvement/s?

419 Lorem ipsum dolor sit amet, consectetur adipiscing elit. Etiam lobortis facilisis sem.
 420 Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec
 421 ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus
 422 placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor.
 423 Praesent in sapien. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Duis fringilla
 424 tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue
 425 a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris.
 426 Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit
 427 amet ipsum. Nunc quis urna dictum turpis accumsan semper.



428 **A2.1.1 What is/are your basis/bases for the improvement/s?**

429 Lorem ipsum dolor sit amet, consectetur adipiscing elit. Etiam lobortis facilisis sem.
 430 Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec
 431 ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus
 432 placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor.
 433 Praesent in sapien. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Duis fringilla
 434 tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue
 435 a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris.
 436 Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit
 437 amet ipsum. Nunc quis urna dictum turpis accumsan semper.

438 **A2.1.2 Why did you choose that/those basis/bases?**

439 Lorem ipsum dolor sit amet, consectetur adipiscing elit. Etiam lobortis facilisis sem.
 440 Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec
 441 ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus
 442 placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor.
 443 Praesent in sapien. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Duis fringilla
 444 tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue
 445 a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris.
 446 Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit
 447 amet ipsum. Nunc quis urna dictum turpis accumsan semper.

448 **A2.1.3 How significant are your measure/s of the improvement/s?**

449 Lorem ipsum dolor sit amet, consectetur adipiscing elit. Etiam lobortis facilisis sem.
 450 Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec
 451 ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus
 452 placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor.
 453 Praesent in sapien. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Duis fringilla
 454 tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue
 455 a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris.
 456 Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit
 457 amet ipsum. Nunc quis urna dictum turpis accumsan semper.



A3 What is the difference of the solution/s from existing ones?

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

A3.1 How is it different from previous and existing ones?

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

A4 What are the assumptions made (that are behind for your proposed solution to work)?

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.



490 **A4.1 Will your proposed solution/s be sensitive to these as-**
 491 **sumptions?**

492 Lorem ipsum dolor sit amet, consectetur adipiscing elit. Etiam lobortis facilisis sem.
 493 Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec
 494 ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus
 495 placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor.
 496 Praesent in sapien. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Duis fringilla
 497 tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue
 498 a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris.
 499 Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit
 500 amet ipsum. Nunc quis urna dictum turpis accumsan semper.

501 **A4.2 Can your proposed solution/s be applied to more general**
 502 **cases when some of the assumptions are eliminated? If**
 503 **so, how?**

504 Lorem ipsum dolor sit amet, consectetur adipiscing elit. Etiam lobortis facilisis sem.
 505 Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec
 506 ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus
 507 placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor.
 508 Praesent in sapien. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Duis fringilla
 509 tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue
 510 a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris.
 511 Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit
 512 amet ipsum. Nunc quis urna dictum turpis accumsan semper.

513 **A5 What is the necessity of your approach / pro-**
 514 **posed solution/s?**

515 Lorem ipsum dolor sit amet, consectetur adipiscing elit. Etiam lobortis facilisis sem.
 516 Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec
 517 ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus
 518 placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor.
 519 Praesent in sapien. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Duis fringilla
 520 tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue
 521 a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris.



522 Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit
523 amet ipsum. Nunc quis urna dictum turpis accumsan semper.

524 **A5.1 What will be the limits of applicability of your proposed so-**
525 **lution/s?**

526 Lorem ipsum dolor sit amet, consectetur adipiscing elit. Etiam lobortis facilisis sem.
527 Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec
528 ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus
529 placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor.
530 Praesent in sapien. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Duis fringilla
531 tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue
532 a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris.
533 Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit
534 amet ipsum. Nunc quis urna dictum turpis accumsan semper.

535 **A5.2 What will be the message of the proposed solution to**
536 **technical people? How about to non-technical managers**
537 **and business men?**

538 Lorem ipsum dolor sit amet, consectetur adipiscing elit. Etiam lobortis facilisis sem.
539 Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec
540 ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus
541 placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor.
542 Praesent in sapien. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Duis fringilla
543 tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue
544 a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris.
545 Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit
546 amet ipsum. Nunc quis urna dictum turpis accumsan semper.

547 **A6 How will you know if your proposed solution/s**
548 **is/are correct?**

549 Lorem ipsum dolor sit amet, consectetur adipiscing elit. Etiam lobortis facilisis sem.
550 Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec
551 ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus
552 placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor.
553 Praesent in sapien. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Duis fringilla



554 tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue
555 a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris.
556 Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit
557 amet ipsum. Nunc quis urna dictum turpis accumsan semper.

558 **A6.1 Will your results warrant the level of mathematics used**
559 **(i.e., will the end justify the means)?**

560 Lorem ipsum dolor sit amet, consectetur adipiscing elit. Etiam lobortis facilisis sem.
561 Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec
562 ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus
563 placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor.
564 Praesent in sapien. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Duis fringilla
565 tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue
566 a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris.
567 Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit
568 amet ipsum. Nunc quis urna dictum turpis accumsan semper.

569 **A7 Is/are there an/_ alternative way/s to get to the**
570 **same solution/s?**

571 Lorem ipsum dolor sit amet, consectetur adipiscing elit. Etiam lobortis facilisis sem.
572 Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec
573 ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus
574 placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor.
575 Praesent in sapien. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Duis fringilla
576 tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue
577 a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris.
578 Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit
579 amet ipsum. Nunc quis urna dictum turpis accumsan semper.

580 **A7.1 Can you come up with illustrating examples, or even bet-**
581 **ter, counter examples to your proposed solution/s?**

582 Lorem ipsum dolor sit amet, consectetur adipiscing elit. Etiam lobortis facilisis sem.
583 Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec
584 ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus
585 placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor.



586 Praesent in sapien. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Duis fringilla
587 tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue
588 a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris.
589 Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit
590 amet ipsum. Nunc quis urna dictum turpis accumsan semper.

591 **A7.2 Is there an approximation that can arrive at the essen-** 592 **tially the same proposed solution/s more easily?**

593 Lorem ipsum dolor sit amet, consectetur adipiscing elit. Etiam lobortis facilisis sem.
594 Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec
595 ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus
596 placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor.
597 Praesent in sapien. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Duis fringilla
598 tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue
599 a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris.
600 Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit
601 amet ipsum. Nunc quis urna dictum turpis accumsan semper.

602 **A8 If you were the examiner of your proposal, how** 603 **would you present the proposal in another way?**

604 Lorem ipsum dolor sit amet, consectetur adipiscing elit. Etiam lobortis facilisis sem.
605 Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec
606 ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus
607 placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor.
608 Praesent in sapien. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Duis fringilla
609 tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue
610 a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris.
611 Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit
612 amet ipsum. Nunc quis urna dictum turpis accumsan semper.

613 **A8.1 What are the weaknesses of your proposal?**

614 Lorem ipsum dolor sit amet, consectetur adipiscing elit. Etiam lobortis facilisis sem.
615 Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec
616 ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus
617 placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor.



618 Praesent in sapien. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Duis fringilla
619 tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue
620 a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris.
621 Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit
622 amet ipsum. Nunc quis urna dictum turpis accumsan semper.



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Appendix B

USAGE EXAMPLES



625 The user is expected to have a working knowledge of \LaTeX . A good introduction is
626 in [?]. Its latest version can be accessed at <http://www.ctan.org/tex-archive/info/lshort>.

627 B1 Equations

628 The following examples show how to typeset equations in \LaTeX . This section also shows
629 examples of the use of `\gls{ }` commands in conjunction with the items that are in
630 the `notation.tex` file. **Please make sure that the entries in `notation.tex` are**
631 **those that are referenced in the \LaTeX document files used by this Thesis Proposal.**
632 **Please comment out unused notations and be careful with the commas and brackets**
633 **in `notation.tex`.**

634 In (B.1), the output signal $y(t)$ is the result of the convolution of the input signal $x(t)$
635 and the impulse response $h(t)$.

$$y(t) = h(t) * x(t) = \int_{-\infty}^{+\infty} h(t - \tau) x(\tau) d\tau \quad (\text{B.1})$$

636 Other example equations are as follows.

$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} V_2 \\ I_2 \end{bmatrix} \quad (\text{B.2})$$

$$\frac{1}{2} < \left[\text{mod} \left(\left\lfloor \frac{y}{17} \right\rfloor 2^{-17\lfloor x \rfloor - \text{mod}(\lfloor y \rfloor, 17)}, 2 \right) \right], \quad (\text{B.3})$$

$$|\zeta(x)^3 \zeta(x + iy)^4 \zeta(x + 2iy)| = \exp \sum_{n,p} \frac{3 + 4 \cos(ny \log p) + \cos(2ny \log p)}{np^{nx}} \geq 1 \quad (\text{B.4})$$



637

The verbatim \LaTeX code of Sec. B1 is in List. B.1.

Listing B.1: Sample \LaTeX code for equations and notations usage

```

1 The following examples show how to typeset equations in \LaTeX.
2
3 In~\eqref{eq:conv}, the output signal \gls{not:output_sigt} is the
  result of the convolution of the input signal \gls{not:input_sigt}
  and the impulse response \gls{not:ir}.
4
5 \begin{eqnarray}
6   y\left( t \right) = h\left( t \right) * x\left( t \right)=\int_{-\infty}^{+\infty}h\left( t-\tau \right)x\left( \tau \right) \mathrm{d}\tau
7   \label{eq:conv}
8 \end{eqnarray}
9
10 Other example equations are as follows.
11
12 \begin{eqnarray}
13   \left[ \dfrac{V_{1}}{I_{1}} \right] =
14   \begin{bmatrix}
15     A & B \\
16     C & D
17   \end{bmatrix}
18   \left[ \dfrac{V_{2}}{I_{2}} \right]
19   \label{eq:ABCD}
20 \end{eqnarray}
21
22 \begin{eqnarray}
23   \{1\over 2\} < \left\lfloor \mathrm{mod}\right\left(\left\lfloor y \over 17\right\right\rfloor 2^{\{-17\lfloor x \rfloor - \mathrm{mod}(\lfloor y \rfloor, 17)\},2\right)\right\rfloor,
24 \end{eqnarray}
25
26 \begin{eqnarray}
27   \left| \zeta(x)^3\zeta(x+iy)^4\zeta(x+2iy) \right| =
28   \exp\sum_{n,p}\frac{3+4\cos(ny\log p) +\cos(2ny\log p)}{n^p}\geq 1
29 \end{eqnarray}

```



B2 Notations

In order to use the standardized notation, the user is highly suggested to see the ISO 80000-2 standard [?]. The following were taken from `isomath-test.tex`.

Math alphabets

If there are other symbols in place of Greek letters in a math alphabet, it uses T1 or OT1 font encoding instead of OML.

<code>mathnormal</code>	$A, B, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Pi, \Sigma, \Phi, \Psi, \Omega, \alpha, \beta, \pi, \nu, \omega, v, w, 0, 1, 9$
<code>mathit</code>	$A, B, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Pi, \Sigma, \Phi, \Psi, \Omega, \textit{ff}, \textit{fi}, \beta, ^\circ, !, v, w, 0, 1, 9$
<code>mathrm</code>	$A, B, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Pi, \Sigma, \Phi, \Psi, \Omega, \text{ff}, \text{fi}, \beta, ^\circ, !, v, w, 0, 1, 9$
<code>mathbf</code>	$\mathbf{A, B, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Pi, \Sigma, \Phi, \Psi, \Omega, ff, fi, \beta, ^\circ, !, v, w, 0, 1, 9}$
<code>mathsf</code>	$A, B, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Pi, \Sigma, \Phi, \Psi, \Omega, \text{ff}, \text{fi}, \beta, ^\circ, !, v, w, 0, 1, 9$
<code>mathtt</code>	$A, B, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Pi, \Sigma, \Phi, \Psi, \Omega, \uparrow, \downarrow, \beta, ^\circ, !, v, w, 0, 1, 9$

New alphabets bold-italic, sans-serif-italic, and sans-serif-bold-italic.

<code>mathbfit</code>	$\mathbf{A, B, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Pi, \Sigma, \Phi, \Psi, \Omega, \alpha, \beta, \pi, \nu, \omega, v, w, 0, 1, 9}$
<code>mathsf</code>	$A, B, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Pi, \Sigma, \Phi, \Psi, \Omega, \alpha, \beta, \pi, \nu, \omega, v, w, 0, 1, 9$
<code>mathsfbfit</code>	$\mathbf{A, B, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Pi, \Sigma, \Phi, \Psi, \Omega, \alpha, \beta, \pi, \nu, \omega, v, w, 0, 1, 9}$

Do the math alphabets match?

$\alpha x \alpha \omega \alpha x \alpha \omega \alpha x \alpha \omega \quad TC\Theta\Gamma TC\Theta\Gamma TC\Theta\Gamma$

Vector symbols

Alphabetic symbols for vectors are boldface italic, $\lambda = e_1 \cdot a$, while numeric ones (e.g. the zero vector) are bold upright, $a + 0 = a$.

Matrix symbols

Symbols for matrices are boldface italic, too:¹ $A = E \cdot A$.

¹However, matrix symbols are usually capital letters whereas vectors are small ones. Exceptions are physical quantities like the force vector F or the electrical field E .

652 **Tensor symbols**

653 Symbols for tensors are sans-serif bold italic,

$$\boldsymbol{\alpha} = \boldsymbol{e} \cdot \boldsymbol{a} \quad \Longleftrightarrow \quad \alpha_{ijl} = e_{ijk} \cdot a_{kl}.$$

654 The permittivity tensor describes the coupling of electric field and displacement:

$$\boldsymbol{D} = \epsilon_0 \boldsymbol{\epsilon}_r \boldsymbol{E}$$



Bold math version

The “bold” math version is selected with the commands `\boldmath` or `\mathversion{bold}`

<code>mathnormal</code>	$A, B, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Pi, \Sigma, \Phi, \Psi, \Omega, \alpha, \beta, \pi, \nu, \omega, v, w, 0, 1, 9$
<code>mathit</code>	$A, B, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Pi, \Sigma, \Phi, \Psi, \Omega, \textit{ff}, \textit{fi}, \beta, ^\circ, !, v, w, 0, 1, 9$
<code>mathrm</code>	$A, B, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Pi, \Sigma, \Phi, \Psi, \Omega, \text{ff}, \text{fi}, \beta, ^\circ, !, v, w, 0, 1, 9$
<code>mathbf</code>	$A, B, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Pi, \Sigma, \Phi, \Psi, \Omega, \text{ff}, \text{fi}, \beta, ^\circ, !, v, w, 0, 1, 9$
<code>mathsf</code>	$\mathbf{A}, \mathbf{B}, \mathbf{\Gamma}, \mathbf{\Delta}, \mathbf{\Theta}, \mathbf{\Lambda}, \mathbf{\Xi}, \mathbf{\Pi}, \mathbf{\Sigma}, \mathbf{\Phi}, \mathbf{\Psi}, \mathbf{\Omega}, \text{ff}, \text{fi}, \beta, ^\circ, !, v, w, 0, 1, 9$
<code>mathtt</code>	$A, B, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Pi, \Sigma, \Phi, \Psi, \Omega, \uparrow, \downarrow, \beta, ^\circ, !, v, w, 0, 1, 9$

New alphabets bold-italic, sans-serif-italic, and sans-serif-bold-italic.

<code>mathbfit</code>	$A, B, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Pi, \Sigma, \Phi, \Psi, \Omega, \alpha, \beta, \pi, \nu, \omega, v, w, 0, 1, 9$
<code>mathsfit</code>	$A, B, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Pi, \Sigma, \Phi, \Psi, \Omega, \alpha, \beta, \pi, \nu, \omega, v, w, 0, 1, 9$
<code>mathsfbfit</code>	$A, B, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Pi, \Sigma, \Phi, \Psi, \Omega, \alpha, \beta, \pi, \nu, \omega, v, w, 0, 1, 9$

Do the math alphabets match?

$\alpha x \alpha \omega a x \alpha \omega a x \alpha \omega \quad TC\Theta\Gamma TC\Theta\Gamma TC\Theta\Gamma$

Vector symbols

Alphabetic symbols for vectors are boldface italic, $\lambda = e_1 \cdot a$, while numeric ones (e.g. the zero vector) are bold upright, $a + 0 = a$.

Matrix symbols

Symbols for matrices are boldface italic, too:² $\Lambda = E \cdot A$.

Tensor symbols

Symbols for tensors are sans-serif bold italic,

$$\alpha = e \cdot a \iff \alpha_{ijl} = e_{ijk} \cdot a_{kl}.$$

The permittivity tensor describes the coupling of electric field and displacement:

$$D = \epsilon_0 \epsilon_r E$$

²However, matrix symbols are usually capital letters whereas vectors are small ones. Exceptions are physical quantities like the force vector F or the electrical field E .



669 The verbatim \LaTeX code of Sec. B2 is in List. B.2.

Listing B.2: Sample \LaTeX code for notations usage

```

670 1 % A teststring with Latin and Greek letters::
671 2 \newcommand{\teststring}{%
672 3 % capital Latin letters
673 4 % A,B,C,
674 5 A,B,
675 6 % capital Greek letters
676 7 %\Gamma,\Delta,\Theta,\Lambda,\Xi,\Pi,\Sigma,\Upsilon,\Phi,\Psi,
677 8 \Gamma,\Delta,\Theta,\Lambda,\Xi,\Pi,\Sigma,\Phi,\Psi,\Omega,
678 9 % small Greek letters
679 10 \alpha,\beta,\pi,\nu,\omega,
680 11 % small Latin letters:
681 12 % compare \nu, \omega, v, and w
682 13 v,w,
683 14 % digits
684 15 0,1,9
685 16 }
686 17
687 18
688 19 \subsection*{Math alphabets}
689 20
690 21 If there are other symbols in place of Greek letters in a math
691 22 alphabet, it uses T1 or OT1 font encoding instead of OML.
692 23
693 24 \begin{eqnarray*}
694 25 \mbox{\mathnormal} & & \mbox{\teststring} \\
695 26 \mbox{\mathit} & & \mbox{\mathit{\teststring}} \\
696 27 \mbox{\mathrm} & & \mbox{\mathrm{\teststring}} \\
697 28 \mbox{\mathbf} & & \mbox{\mathbf{\teststring}} \\
698 29 \mbox{\mathsf} & & \mbox{\mathsf{\teststring}} \\
699 30 \mbox{\mathtt} & & \mbox{\mathtt{\teststring}} \\
700 31 \end{eqnarray*}
701 32 New alphabets bold-italic, sans-serif-italic, and sans-serif-bold-
702 33 italic.
703 34 \begin{eqnarray*}
704 35 \mbox{\mathbfit} & & \mbox{\mathbfit{\teststring}} \\
705 36 \mbox{\mathsf fit} & & \mbox{\mathsf fit{\teststring}} \\
706 37 \mbox{\mathsf bfit} & & \mbox{\mathsf bfit{\teststring}} \\
707 38 \end{eqnarray*}
708 39 %
709 40 Do the math alphabets match?
710 41 $
711 42 \mathnormal {a x \alpha \omega}
712 43 \mathbfit {a x \alpha \omega}
713 44 \mathsf bfit {a x \alpha \omega}
714 45 \quad
715 46 \mathsf bfit {T C \Theta \Gamma}
716 47 \mathbfit {T C \Theta \Gamma}
717 48 \mathnormal {T C \Theta \Gamma}
718 49 $
719 50
720 51 \subsection*{Vector symbols}
721 52

```



```

724 53 Alphabetic symbols for vectors are boldface italic,
725 54  $\vec{\lambda} = \vec{e}_1 \cdot \vec{a}$ ,
726 55 while numeric ones (e.g. the zero vector) are bold upright,
727 56  $\vec{a} + \vec{0} = \vec{a}$ .
728 57
729 58 \subsection*{Matrix symbols}
730 59
731 60 Symbols for matrices are boldface italic, too:%
732 61 \footnote{However, matrix symbols are usually capital letters whereas
733 62 vectors
734 62 are small ones. Exceptions are physical quantities like the force
735 63 vector  $\vec{F}$  or the electrical field  $\vec{E}$ .%
736 64 }
737 65  $\Lambda = E \cdot A$ .
738 66
739 67
740 68 \subsection*{Tensor symbols}
741 69
742 70 Symbols for tensors are sans-serif bold italic,
743 71
744 72 \[
745 73 \quad \text{\textbf{\textit{tensorsym{\alpha} = tensorsym{e} \cdot tensorsym{a}}}}
746 74 \quad \text{\textbf{\textit{quad \Longleftarrow \rightarrow quad}}}
747 75 \quad \text{\textbf{\textit{\alpha_{ijl} = e_{ijk} \cdot a_{kl}}}}
748 76 \]
749 77
750 78
751 79 The permittivity tensor describes the coupling of electric field and
752 80 displacement: \[
753 81 \vec{D} = \epsilon_0 \text{\textbf{\textit{tensorsym{\epsilon}_{\mathrm{r}}}}} \vec{E} \]
754 82
755 83
756 84
757 85 \newpage
758 86 \subsection*{Bold math version}
759 87
760 88 The ‘‘bold’’ math version is selected with the commands
761 89 \verb+\boldmath+ or \verb+\mathversion{bold}+
762 90
763 91 {\boldmath
764 92 \begin{eqnarray*}
765 93 \quad \text{\textbf{\textit{mbox{mathnormal}}} & & \text{\textbf{\textit{teststring}}} \\
766 94 \quad \text{\textbf{\textit{mbox{mathit}}} & & \text{\textbf{\textit{mathit{teststring}}}}} \\
767 95 \quad \text{\textbf{\textit{mbox{mathrm}}} & & \text{\textbf{\textit{mathrm{teststring}}}}} \\
768 96 \quad \text{\textbf{\textit{mbox{mathbf}}} & & \text{\textbf{\textit{mathbf{teststring}}}}} \\
769 97 \quad \text{\textbf{\textit{mbox{mathsf}}} & & \text{\textbf{\textit{mathsf{teststring}}}}} \\
770 98 \quad \text{\textbf{\textit{mbox{mathtt}}} & & \text{\textbf{\textit{mathtt{teststring}}}}} \\
771 99 \end{eqnarray*}
772 100 \quad \text{New alphabets bold-italic, sans-serif-italic, and sans-serif-bold-}
773 101 \quad \text{italic.}
774 102 \begin{eqnarray*}
775 103 \quad \text{\textbf{\textit{mbox{mathbfit}}} & & \text{\textbf{\textit{mathbfit{teststring}}}}} \\
776 104 \quad \text{\textbf{\textit{mbox{mathsf}}} & & \text{\textbf{\textit{mathsf{teststring}}}}} \\
777 105 \quad \text{\textbf{\textit{mbox{mathsfbfit}}} & & \text{\textbf{\textit{mathsfbfit{teststring}}}}} \\
778 106 \end{eqnarray*}
779 107 \%
780 108 Do the math alphabets match?

```



```

781 108 $
782 109 $
783 110 \mathnormal {a x \alpha \omega}
784 111 \mathbf{fit} {a x \alpha \omega}
785 112 \mathsf{fbfit}{a x \alpha \omega}
786 113 \quad
787 114 \mathsf{fbfit}{T C \Theta \Gamma}
788 115 \mathbf{fit} {T C \Theta \Gamma}
789 116 \mathnormal {T C \Theta \Gamma}
790 117 $
791 118
792 119 \subsection*{Vector symbols}
793 120
794 121 Alphabetic symbols for vectors are boldface italic,
795 122 $\vec{\lambda}=\vec{e}_1\cdot\vec{a}$,
796 123 while numeric ones (e.g. the zero vector) are bold upright,
797 124 $\vec{a} + \vec{0} = \vec{a}$.
798 125
799 126
800 127
801 128
802 129 \subsection*{Matrix symbols}
803 130
804 131 Symbols for matrices are boldface italic, too:%
805 132 \footnote{However, matrix symbols are usually capital letters whereas
806 133 vectors
807 134 are small ones. Exceptions are physical quantities like the force
808 135 vector $\vec{F}$ or the electrical field $\vec{E}$.%
809 136 }
810 137 $\matrixsym{\Lambda}=\matrixsym{E}\cdot\matrixsym{A}.$
811 138
812 139
813 140 \subsection*{Tensor symbols}
814 141
815 142 Symbols for tensors are sans-serif bold italic,
816 143
817 144 \[
818 145 \quad \Longleftrightarrow \quad
819 146 \alpha_{ijl} = e_{ijk}\cdot a_{kl}.
820 147
821 148 \]
822 149
823 150 The permittivity tensor describes the coupling of electric field and
824 151 displacement: \[
825 152 \vec{D}=\epsilon_0\tensorsym{\epsilon}_{\mathrm{r}}\vec{E}\]

```



B3 Abbreviation

This section shows examples of the use of \LaTeX commands in conjunction with the items that are in the `abbreviation.tex` and in the `glossary.tex` files. Please see List. B.3. **To lessen the \LaTeX compilation time, it is suggested that you use `\acr{ }` only for the first occurrence of the word to be abbreviated.**

Again please see List. B.3. Here is an example of first use: alternating current (ac). Next use: ac. Full: alternating current (ac). Here's an acronym referenced using `\acr` : hyper-text markup language (html). And here it is again: html. If you are used to the glossaries package, note the difference in using `\gls` : hyper-text markup language (html). And again (no difference): hyper-text markup language (html). Here are some more entries:

- extensible markup language (xml) and cascading style sheet (css).
- Next use: xml and css.
- Full form: extensible markup language (xml) and cascading style sheet (css).
- Reset again.
- Start with a capital. Hyper-text markup language (html).
- Next: Html. Full: Hyper-text markup language (html).
- Prefer capitals? Extensible markup language (XML). Next: XML. Full: extensible markup language (XML).
- Prefer small-caps? Cascading style sheet (CSS). Next: CSS. Full: cascading style sheet (CSS).
- Resetting all acronyms.
- Here are the acronyms again:
- Hyper-text markup language (HTML), extensible markup language (XML) and cascading style sheet (CSS).
- Next use: HTML, XML and CSS.
- Full form: Hyper-text markup language (HTML), extensible markup language (XML) and cascading style sheet (CSS).



- 857 • Provide your own link text: style sheet.

858 The verbatim \LaTeX code of Sec. B3 is in List. B.3.

Listing B.3: Sample \LaTeX code for abbreviations usage

```

1 Again please see List.~\ref{lst:abbrv}. Here is an example of first use:
  \acr{ac}. Next use: \acr{ac}. Full: \gls{ac}. Here's an acronym
  referenced using \verb| \acr |: \acr{html}. And here it is again: \
  acr{html}. If you are used to the \texttt{glossaries} package, note
  the difference in using \verb| \gls |: \gls{html}. And again (no
  difference): \gls{html}. Here are some more entries:
2
3 \begin{itemize}
4
5   \item \acr{xml} and \acr{css}.
6
7   \item Next use: \acr{xml} and \acr{css}.
8
9   \item Full form: \gls{xml} and \gls{css}.
10
11  \item Reset again. \glsresetall{abbreviation}
12
13  \item Start with a capital. \Acr{html}.
14
15  \item Next: \Acr{html}. Full: \Gls{html}.
16
17  \item Prefer capitals? \renewcommand{\acronymfont}[1]{\
    MakeTextUppercase{#1}} \Acr{xml}. Next: \acr{xml}. Full: \gls{xml}
    }.
18
19  \item Prefer small-caps? \renewcommand{\acronymfont}[1]{\textsc{#1}}
    \Acr{css}. Next: \acr{css}. Full: \gls{css}.
20
21  \item Resetting all acronyms.\glsresetall{abbreviation}
22
23  \item Here are the acronyms again:
24
25  \item \Acr{html}, \acr{xml} and \acr{css}.
26
27  \item Next use: \Acr{html}, \acr{xml} and \acr{css}.
28
29  \item Full form: \Gls{html}, \gls{xml} and \gls{css}.
30
31  \item Provide your own link text: \glslink{[textbf]css}{style}
32
33 \end{itemize}

```



B4 Glossary

This section shows examples of the use of `\gls{ }` commands in conjunction with the items that are in the `glossary.tex` and `notation.tex` files. Note that entries in `notation.tex` are prefixed with “not:” label (see List. B.4).

Please make sure that the entries in `notation.tex` are those that are referenced in the \LaTeX document files used by this Thesis Proposal. Please comment out unused notations and be careful with the commas and brackets in `notation.tex`.

- Matrices are usually denoted by a bold capital letter, such as A . The matrix’s (i, j) th element is usually denoted a_{ij} . Matrix I is the identity matrix.
- A set, denoted as S , is a collection of objects.
- The universal set, denoted as \mathcal{U} , is the set of everything.
- The empty set, denoted as \emptyset , contains no elements.
- The cardinality of a set, denoted as $|S|$, is the number of elements in the set.

The verbatim \LaTeX code for the part of Sec. B4 is in List. B.4.

Listing B.4: Sample \LaTeX code for glossary and notations usage

```

1 \begin{itemize}
2
3   \item \Glspl{matrix} are usually denoted by a bold capital letter,
      such as  $\mathbf{A}$ . The  $\gls{matrix}$ ’s  $(i, j)$ th element is
      usually denoted  $a_{ij}$ .  $\gls{matrix}$   $\mathbf{I}$  is the
      identity  $\gls{matrix}$ .
4
5   \item A set, denoted as  $\gls{not:set}$ , is a collection of objects.
6
7   \item The universal set, denoted as  $\gls{not:universalSet}$ , is the
      set of everything.
8
9   \item The empty set, denoted as  $\gls{not:emptySet}$ , contains no
      elements.
10
11   \item The cardinality of a set, denoted as  $\gls{not:cardinality}$ , is
      the number of elements in the set.
12
13 \end{itemize}
```



873 **B5 Figure**

874 This section shows several ways of placing figures. PDFL^AT_EX compatible files are PDF,
875 PNG, and JPG. Please see the `figure` subdirectory.

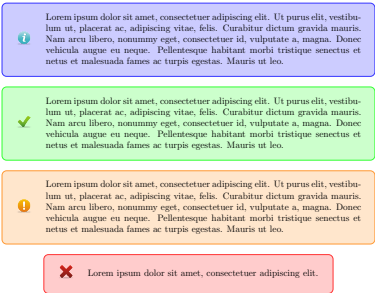


Fig. B.1 A quadrilateral image example.



876

877

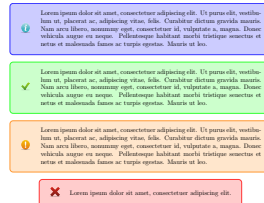
Fig. B.1 is a gray box enclosed by a dark border. List. B.5 shows the corresponding \LaTeX code.

Listing B.5: Sample \LaTeX code for a single figure

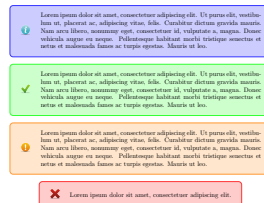
```
1 \begin{figure}[!htbp]
2   \centering
3   \includegraphics[width=0.5\textwidth]{example}
4   \caption{A quadrilateral image example.}
5   \label{fig:example}
6 \end{figure}
7 \cleardoublepage
8
9 Fig.~\ref{fig:example} is a gray box enclosed by a dark border. List.~\ref{lst:onefig} shows the corresponding  $\text{\LaTeX}$  \ code.
10 \end{figure}
```



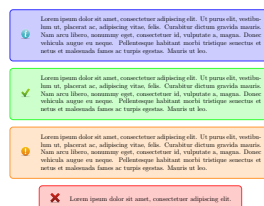
De La Salle University



(a) A sub-figure in the top row.



(b) A sub-figure in the middle row.

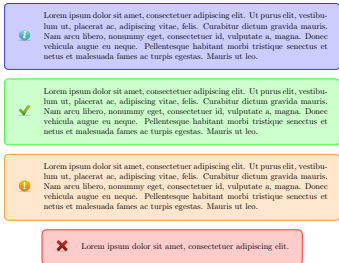


(c) A sub-figure in the bottom row.

Listing B.6: Sample L^AT_EX code for three figures on top of each other

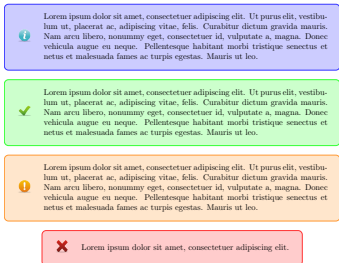
```
1 \begin{figure}[!htbp]
2 \centering
3 \subbottom[A sub-figure in the top row.]{
4 \includegraphics[width=0.35\textwidth]{example}
5 \label{fig:top}
6 }
7 \vfill
8 \subbottom[A sub-figure in the middle row.]{
9 \includegraphics[width=0.35\textwidth]{example}
10 \label{fig:mid}
11 }
12 \vfill
13 \subbottom[A sub-figure in the bottom row.]{
14 \includegraphics[width=0.35\textwidth]{example}
15 \label{fig:botm}
16 }
17 \caption{Figures on top of each other}
18 \label{fig:tmb}
19 \end{figure}
```

B. Usage Examples



(a) A sub-figure in the upper-left corner.

(b) A sub-figure in the upper-right corner.



(c) A sub-figure in the lower-left corner.

(d) A sub-figure in the lower-right corner

Fig. B.3 Four figures in each corner. See List. B.7 for the corresponding \LaTeX code.

Listing B.7: Sample \LaTeX code for the four figures

```

1 \begin{figure}[!htbp]
2 \centering
3 \subbottom[A sub-figure in the upper-left corner.]{
4 \includegraphics[width=0.45\textwidth]{example}
5 \label{fig:upprleft}
6 }
7 \hfill
8 \subbottom[A sub-figure in the upper-right corner.]{
9 \includegraphics[width=0.45\textwidth]{example}
10 \label{fig:uppright}
11 }
12 \vfill
13 \subbottom[A sub-figure in the lower-left corner.]{
14 \includegraphics[width=0.45\textwidth]{example}
15 \label{fig:lowerleft}
16 }
17 \hfill
18 \subbottom[A sub-figure in the lower-right corner]{
19 \includegraphics[width=0.45\textwidth]{example}
20 \label{fig:lowright}
21 }
22 \caption{Four figures in each corner. See List.\ref{lst:fourfigs} for
23 the corresponding \LaTeX \ code.}
24 \label{fig:fourfig}
25 \end{figure}

```



878

B6 Table

879

This section shows an example of placing a table (a long one). Table B.1 are the triples.

TABLE B.1 FEASIBLE TRIPLES FOR HIGHLY VARIABLE GRID

Time (s)	Triple chosen	Other feasible triples
0	(1, 11, 13725)	(1, 12, 10980), (1, 13, 8235), (2, 2, 0), (3, 1, 0)
2745	(1, 12, 10980)	(1, 13, 8235), (2, 2, 0), (2, 3, 0), (3, 1, 0)
5490	(1, 12, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
8235	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
10980	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
13725	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
16470	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
19215	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
21960	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
24705	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
27450	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
30195	(2, 2, 2745)	(2, 3, 0), (3, 1, 0)
32940	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
35685	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
38430	(1, 13, 10980)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
41175	(1, 12, 13725)	(1, 13, 10980), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
43920	(1, 13, 10980)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
46665	(2, 2, 2745)	(2, 3, 0), (3, 1, 0)
49410	(2, 2, 2745)	(2, 3, 0), (3, 1, 0)
52155	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
54900	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
57645	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
60390	(1, 12, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
63135	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
65880	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
68625	(2, 2, 2745)	(2, 3, 0), (3, 1, 0)
71370	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
74115	(1, 12, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
76860	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
79605	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
82350	(1, 12, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
85095	(1, 12, 13725)	(1, 13, 10980), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
87840	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
90585	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
93330	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
96075	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
98820	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
101565	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
104310	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
107055	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
109800	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
112545	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
115290	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
118035	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
120780	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
123525	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)

Continued on next page



Continued from previous page

Time (s)	Triple chosen	Other feasible triples
126270	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
129015	(2, 2, 2745)	(2, 3, 0), (3, 1, 0)
131760	(2, 2, 2745)	(2, 3, 0), (3, 1, 0)
134505	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
137250	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
139995	(2, 2, 2745)	(2, 3, 0), (3, 1, 0)
142740	(2, 2, 2745)	(2, 3, 0), (3, 1, 0)
145485	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
148230	(2, 2, 2745)	(2, 3, 0), (3, 1, 0)
150975	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
153720	(1, 12, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
156465	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
159210	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
161955	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
164700	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)



881 List. B.8 shows the corresponding \LaTeX code.

Listing B.8: Sample \LaTeX code for making typical table environment

```

882 1 \begin{center}
883 2 {\scriptsize
884 3 \begin{tabularx}{\textwidth}{p{0.1\textwidth}|p{0.2\textwidth}|p{0.5\textwidth}}
885 4 \caption{Feasible triples for highly variable grid} \label{tab:triple_
886 5 grid} \\
887 6 \hline
888 7 \textbf{Time (s)} &
889 8 \textbf{Triple chosen} &
890 9 \textbf{Other feasible triples} \\
891 10 \hline
892 11 \endfirsthead
893 12 \multicolumn{3}{c}{\textit{Continued from previous page}} \\
894 13 \hline
895 14 \hline
896 15 \textbf{Time (s)} &
897 16 \textbf{Triple chosen} &
898 17 \textbf{Other feasible triples} \\
899 18 \hline
900 19 \endhead
901 20 \hline
902 21 \hline
903 22 \multicolumn{3}{r}{\textit{Continued on next page}} \\
904 23 \endfoot
905 24 \hline
906 25 \endlastfoot
907 26 \hline
908 27
909 28 0 & (1, 11, 13725) & (1, 12, 10980), (1, 13, 8235), (2, 2, 0), (3, 1, 0) \\
910 29 & & \\
911 30 2745 & (1, 12, 10980) & (1, 13, 8235), (2, 2, 0), (2, 3, 0), (3, 1, 0) \\
912 31 & & \\
913 32 5490 & (1, 12, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
914 33 8235 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
915 34 10980 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
916 35 13725 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
917 36 16470 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
918 37 19215 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
919 38 21960 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
920 39 24705 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
921 40 27450 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
922 41 30195 & (2, 2, 2745) & (2, 3, 0), (3, 1, 0) \\
923 42 32940 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
924 43 35685 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
925 44 38430 & (1, 13, 10980) & (2, 2, 2745), (2, 3, 0), (3, 1, 0)

```




```

936 43 41175 & (1, 12, 13725) & (1, 13, 10980), (2, 2, 2745), (2, 3, 0), (3, 1,
937 0) \\
938 44 43920 & (1, 13, 10980) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
939 45 46665 & (2, 2, 2745) & (2, 3, 0), (3, 1, 0) \\
940 46 49410 & (2, 2, 2745) & (2, 3, 0), (3, 1, 0) \\
941 47 52155 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1,
942 0) \\
943 48 54900 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
944 49 57645 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
945 50 60390 & (1, 12, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
946 51 63135 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
947 52 65880 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
948 53 68625 & (2, 2, 2745) & (2, 3, 0), (3, 1, 0) \\
949 54 71370 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
950 55 74115 & (1, 12, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
951 56 76860 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
952 57 79605 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
953 58 82350 & (1, 12, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
954 59 85095 & (1, 12, 13725) & (1, 13, 10980), (2, 2, 2745), (2, 3, 0), (3, 1,
955 0) \\
956 60 87840 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
957 61 90585 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
958 62 93330 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
959 63 96075 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
960 64 98820 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
961 65 101565 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
962 66 104310 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
963 67 107055 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
964 68 109800 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
965 69 112545 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3,
966 1, 0) \\
967 70 115290 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
968 71 118035 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
969 72 120780 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
970 73 123525 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
971 74 126270 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3,
972 1, 0) \\
973 75 129015 & (2, 2, 2745) & (2, 3, 0), (3, 1, 0) \\
974 76 131760 & (2, 2, 2745) & (2, 3, 0), (3, 1, 0) \\
975 77 134505 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
976 78 137250 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
977 79 139995 & (2, 2, 2745) & (2, 3, 0), (3, 1, 0) \\
978 80 142740 & (2, 2, 2745) & (2, 3, 0), (3, 1, 0) \\
979 81 145485 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3,
980 1, 0) \\
981 82 148230 & (2, 2, 2745) & (2, 3, 0), (3, 1, 0) \\
982 83 150975 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
983 84 153720 & (1, 12, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
984 85 156465 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
985 86 159210 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
986 87 161955 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
987 88 164700 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
988 89 \end{tabularx}
989 90 }
990 91 \end{center}

```



992 **B7 Algorithm or Pseudocode Listing**

993 Table B.2 shows an example pseudocode. Note that if the pseudocode exceeds one page, it
994 can mean that its implementation is not modular. List. B.9 shows the corresponding L^AT_EX
995 code.

TABLE B.2 CALCULATION OF $y = x^n$

Input(s):	
n	: n th power; $n \in \mathbb{Z}^+$
x	: base value; $x \in \mathbb{R}^+$
Output(s):	
y	: result; $y \in \mathbb{R}^+$

```
Require:  $n \geq 0 \vee x \neq 0$ 
Ensure:  $y = x^n$ 
1:  $y \leftarrow 1$ 
2: if  $n < 0$  then
3:    $X \leftarrow 1/x$ 
4:    $N \leftarrow -n$ 
5: else
6:    $X \leftarrow x$ 
7:    $N \leftarrow n$ 
8: end if
9: while  $N \neq 0$  do
10:  if  $N$  is even then
11:     $X \leftarrow X \times X$ 
12:     $N \leftarrow N/2$ 
13:  else  $\{N$  is odd $\}$ 
14:     $y \leftarrow y \times X$ 
15:     $N \leftarrow N - 1$ 
16:  end if
17: end while
```

Listing B.9: Sample L^AT_EX code for algorithm or pseudocode listing usage

```

1 \begin{table}[!htbp]
2   \caption{Calculation of  $y = x^n$ }
3   \label{tab:calcxn}
4   {\footnotesize
5     \begin{tabular}{lll}
6       \hline
7       \hline
8       {\bfseries Input(s):} & & \\
9       $n$ & : & $n$th power; $n$ \in \mathbb{Z}^{+}$ \\
10      $x$ & : & base value; $x$ \in \mathbb{R}^{+}$ \\
11      \hline
12      {\bfseries Output(s):} & & \\
13      $y$ & : & result; $y$ \in \mathbb{R}^{+}$ \\
14      \hline
15      \hline
16      \\
17    \end{tabular}
18  }
19  \begin{algorithmic}[1]
20    {\footnotesize
21      \REQUIRE $n \geq 0$ \vee $x \neq 0$
22      \ENSURE $y = x^n$
23      \STATE $y \leftarrow 1$
24      \IF{$n < 0$}
25        \STATE $X \leftarrow 1 / x$
26        \STATE $N \leftarrow -n$
27      \ELSE
28        \STATE $X \leftarrow x$
29        \STATE $N \leftarrow n$
30      \ENDIF
31      \WHILE{$N \neq 0$}
32        \IF{$N$ is even}
33          \STATE $X \leftarrow X \times X$
34          \STATE $N \leftarrow N / 2$
35        \ELSE[$N$ is odd]
36          \STATE $y \leftarrow y \times X$
37          \STATE $N \leftarrow N - 1$
38        \ENDIF
39      \ENDWHILE
40    }
41  \end{algorithmic}
42 \end{table}

```



B8 Program/Code Listing

List. B.10 is a program listing of a C code for computing Fibonacci numbers by calling the actual code. Please see the `code` subdirectory.

Listing B.10: Computing Fibonacci numbers in C (./code/fibo.c)

```

1  /* fibo.c -- It prints out the first N Fibonacci
2  *              numbers.
3  */
4
5  #include <stdio.h>
6
7  int main(void) {
8      int n;          /* Number of fibonacci numbers we will print */
9      int i;          /* Index of fibonacci number to be printed next */
10     int current;     /* Value of the (i)th fibonacci number */
11     int next;        /* Value of the (i+1)th fibonacci number */
12     int twoaway;     /* Value of the (i+2)th fibonacci number */
13
14     printf("How many Fibonacci numbers do you want to compute? ");
15     scanf("%d", &n);
16     if (n<=0)
17         printf("The number should be positive.\n");
18     else {
19         printf("\n\n\tI\t\tFibonacci(I)\t\n\t===== \n");
20         next = current = 1;
21         for (i=1; i<=n; i++) {
22             printf("\t%d\t\t\t%d\n", i, current);
23             twoaway = current+next;
24             current = next;
25             next = twoaway;
26         }
27     }
28 }
29
30 /* The output from a run of this program was:
31
32 How many Fibonacci numbers do you want to compute? 9
33
34     I      Fibonacci(I)
35     =====
36     1      1
37     2      1
38     3      2
39     4      3
40     5      5
41     6      8
42     7     13
43     8     21
44     9     34
45
46 */

```



999

List. B.11 shows the corresponding \LaTeX code.

Listing B.11: Sample \LaTeX code for program listing

```
1 List.~\ref{lst:fib_c} is a program listing of a C code for computing  
   Fibonacci numbers by calling the actual code. Please see the \verb|  
   code | subdirectory.
```



B9 Referencing

Referencing chapters: This appendix is in Appendix B, which is about examples in using various \LaTeX commands.

Referencing sections: This section is Sec. B9, which shows how to refer to the locations of various labels that have been placed in the \LaTeX files. List. B.12 shows the corresponding \LaTeX code.

Listing B.12: Sample \LaTeX code for referencing sections

```
1 Referencing sections: This section is Sec.~\ref{sec:ref}, which shows
   how to refer to the locations of various labels that have been
   placed in the \LaTeX \ files. List.~\ref{lst:refsec} shows the
   corresponding \LaTeX \ code.
```

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B9.1 A subsection

Referencing subsections: This section is Sec. B9.1, which shows how to refer to a subsection. List. B.13 shows the corresponding \LaTeX code.

Listing B.13: Sample \LaTeX code for referencing subsections

```
1 Referencing subsections: This section is Sec.~\ref{sec:subsec}, which
  shows how to refer to a subsection. List.~\ref{lst:refsub} shows the
  corresponding \LaTeX \ code.
```

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.



B9.1.1 A sub-subsection

Referencing sub-subsections: This section is Sec. B9.1.1, which shows how to refer to a sub-subsection. List. B.14 shows the corresponding \LaTeX code.

Listing B.14: Sample \LaTeX code for referencing sub-subsections

```
1 Referencing sub-subsections: This section is Sec.\ref{sec:subsubsec},
  which shows how to refer to a sub-subsection. List.\ref{lst:
  refsubsub} shows the corresponding \LaTeX \ code.
```

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.



B10 Index

For key words or topics that are expected (or the user would like) to appear in the Index, use `\index{key}`, where `key` is an example keyword to appear in the Index. For example, Fredholm integral and Fourier operator of the following paragraph are in the Index.

If we make a very large matrix with complex exponentials in the rows (i.e., cosine real parts and sine imaginary parts), and increase the resolution without bound, we approach the kernel of the Fredholm integral equation of the 2nd kind, namely the Fourier operator that defines the continuous Fourier transform.

List. B.15 is a program listing of the above-mentioned paragraph.

Listing B.15: Sample \LaTeX code for Index usage

```
1 If we make a very large matrix with complex exponentials in the rows (i.
  e., cosine real parts and sine imaginary parts), and increase the
  resolution without bound, we approach the kernel of the \index{
  Fredholm integral} Fredholm integral equation of the 2nd kind,
  namely the \index{Fourier} Fourier operator that defines the
  continuous Fourier transform.
```



B11 Adding Relevant PDF Pages (e.g. Standards, Datasheets, Specification Sheets, Application Notes, etc.)

Selected PDF pages can be added (see List. B.16), but note that the options must be tweaked. See the manual of `pdfpages` for other options.

Listing B.16: Sample \LaTeX code for including PDF pages

```
1 \includepdf[pages={8-10},%
2 offset=3.5mm -10mm,%
3 scale=0.73,%
4 frame]
5 {./reference/Xilinx2015-UltraScaleArchitectureOverview.pdf}
```



Virtex UltraScale FPGA Feature Summary

Table 6: Virtex UltraScale FPGA Feature Summary

	VU065	VU080	VU095	VU125	VU160	VU190	VU440
Logic Cells	626,640	780,000	940,800	1,253,280	1,621,200	1,879,920	4,432,680
CLB Flip-Flops	716,160	891,424	1,075,200	1,432,320	1,852,800	2,148,480	5,065,920
CLB LUTs	358,080	445,712	537,600	716,160	926,400	1,074,240	2,532,960
Maximum Distributed RAM (Mb)	4.8	3.9	4.8	9.7	12.7	14.5	28.7
Block RAM/FIFO w/ECC (36Kb each)	1,260	1,421	1,728	2,520	3,276	3,780	2,520
Total Block RAM (Mb)	44.3	50.0	60.8	88.6	115.2	132.9	88.6
CMT (1 MMCM, 2 PLLs)	10	16	16	20	30	30	30
I/O DLLs	40	64	64	80	120	120	120
Fractional PLLs	5	8	8	10	15	15	0
Maximum HP I/Os ⁽¹⁾	468	780	780	780	650	650	1,404
Maximum HR I/Os ⁽²⁾	52	52	52	104	52	52	52
DSP Slices	600	672	768	1,200	1,560	1,800	2,880
System Monitor	1	1	1	2	3	3	3
PCIe Gen3 x8	2	4	4	4	5	6	6
150G Interlaken	3	6	6	6	8	9	0
100G Ethernet	3	4	4	6	9	9	3
GTH 16.3Gb/s Transceivers	20	32	32	40	52	60	48
GTY 30.5Gb/s Transceivers	20	32	32	40	52	60	0

Notes:

1. HP = High-performance I/O with support for I/O voltage from 1.0V to 1.8V.
2. HR = High-range I/O with support for I/O voltage from 1.2V to 3.3V.



Virtex UltraScale Device-Package Combinations and Maximum I/Os

Table 7: Virtex UltraScale Device-Package Combinations and Maximum I/Os

Package ⁽¹⁾⁽²⁾⁽³⁾	Package Dimensions (mm)	VU065	VU080	VU095	VU125	VU160	VU190	VU440
		HR, HP GTH, GTY	HR, HP GTH, GTY	HR, HP GTH, GTY	HR, HP GTH, GTY	HR, HP GTH, GTY	HR, HP GTH, GTY	HR, HP GTH, GTY
FFVC1517	40x40	52, 468 20, 20	52, 468 20, 20	52, 468 20, 20				
FFVD1517	40x40		52, 286 32, 32	52, 286 32, 32				
FLVD1517	40x40				52, 286 40, 32			
FFVB1760	42.5x42.5		52, 650 32, 16	52, 650 32, 16				
FLVB1760	42.5x42.5				52, 650 36, 16			
FFVA2104	47.5x47.5		52, 780 28, 24	52, 780 28, 24				
FLVA2104	47.5x47.5				52, 780 28, 24			
FFVB2104	47.5x47.5		52, 650 32, 32	52, 650 32, 32				
FLVB2104	47.5x47.5				52, 650 40, 36			
FLGB2104	47.5x47.5					52, 650 40, 36	52, 650 40, 36	
FFVC2104	47.5x47.5			52, 364 32, 32				
FLVC2104	47.5x47.5				52, 364 40, 40			
FLGC2104	47.5x47.5					52, 364 52, 52	52, 364 52, 52	
FLGB2377	50x50							52, 1248 36, 0
FLGA2577	52.5x52.5						0, 448 60, 60	
FLGA2892	55x55							52, 1404 48, 0

Notes:

1. Go to [Ordering Information](#) for package designation details.
2. All packages have 1.0mm ball pitch.
3. Packages with the same last letter and number sequence, e.g., A2104, are footprint compatible with all other UltraScale architecture-based devices with the same sequence. The footprint compatible devices within this family are outlined. See the [UltraScale Architecture Product Selection Guide](#) for details on inter-family migration.



Virtex UltraScale+ FPGA Feature Summary

Table 8: Virtex UltraScale+ FPGA Feature Summary

	VU3P	VU5P	VU7P	VU9P	VU11P	VU13P
Logic Cells	689,640	1,051,010	1,379,280	2,068,920	2,147,040	2,862,720
CLB Flip-Flops	788,160	1,201,154	1,576,320	2,364,480	2,453,760	3,271,680
CLB LUTs	394,080	600,577	788,160	1,182,240	1,226,880	1,635,840
Max. Distributed RAM (Mb)	12.0	18.3	24.1	36.1	34.8	46.4
Block RAM/FIFO w/ECC (36Kb each)	720	1,024	1,440	2,160	2,016	2,688
Block RAM (Mb)	25.3	36.0	50.6	75.9	70.9	94.5
UltraRAM Blocks	320	470	640	960	1,152	1,536
UltraRAM (Mb)	90.0	132.2	180.0	270.0	324.0	432.0
CMTs (1 MMCM and 2 PLLs)	10	20	20	30	12	16
Max. HP I/O ⁽¹⁾	520	832	832	832	624	832
DSP Slices	2,280	3,474	4,560	6,840	8,928	11,904
System Monitor	1	2	2	3	3	4
GTY Transceivers 32.75Gb/s	40	80	80	120	96	128
PCIe Gen3 x16 and Gen4 x8	2	4	4	6	3	4
150G Interlaken	3	4	6	9	9	12
100G Ethernet w/RS-FEC	3	4	6	9	6	8

Notes:

1. HP = High-performance I/O with support for I/O voltage from 1.0V to 1.8V.

Virtex UltraScale+ Device-Package Combinations and Maximum I/Os

Table 9: Virtex UltraScale+ Device-Package Combinations and Maximum I/Os

Package (1)(2)(3)	Package Dimensions (mm)	VU3P	VU5P	VU7P	VU9P	VU11P	VU13P
		HP, GTY	HP, GTY	HP, GTY	HP, GTY	HP, GTY	HP, GTY
FFVC1517	40x40	520, 40					
FLVF1924	45x45					624, 64	
FLVA2104	47.5x47.5		832, 52	832, 52	832, 52		
FHVA2104	52.5x52.5 ⁽⁴⁾						832, 52
FLVB2104	47.5x47.5		702, 76	702, 76	702, 76	624, 76	
FHVB2104	52.5x52.5 ⁽⁴⁾						702, 76
FLVC2104	47.5x47.5		416, 80	416, 80	416, 104	416, 96	
FHVC2104	52.5x52.5 ⁽⁴⁾						416, 104
FLVA2577	52.5x52.5				448, 120	448, 96	448, 128

Notes:

1. Go to [Ordering Information](#) for package designation details.
2. All packages have 1.0mm ball pitch.
3. Packages with the same last letter and number sequence, e.g., A2104, are footprint compatible with all other UltraScale devices with the same sequence. The footprint compatible devices within this family are outlined.
4. These 52.5x52.5mm overhang packages have the same PCB ball footprint as the corresponding 47.5x47.5mm packages (i.e., the same last letter and number sequence) and are footprint compatible.



Appendix C

PUBLICATION LIST AND AWARD

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Award

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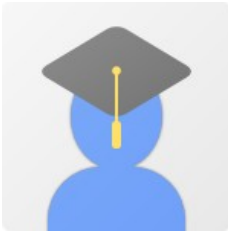
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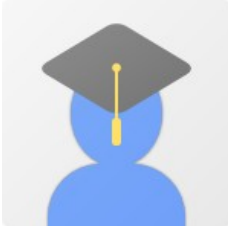
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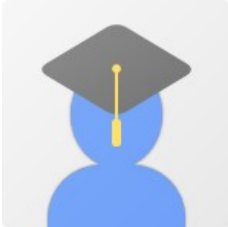
Appendix D VITA



Paul Vince A. Abe is pursuing a Bachelor's Degree in Computer Engineering at De La Salle University-Manila. His role in the group is the Core Researcher. Along with his extensive ability in correlating needed topics in specifying both the strengths and projected weaknesses of the project, he contributes mainly in creating the knowledge pool of the group.



Joanna Katherine U. Mirida is pursuing a Bachelor's Degree in Computer Engineering at De La Salle University-Manila. His role in the group is the Master Programmer. With his adept skills in computer programming, he functions as the brain of the project, as he provides the main idea along with its purpose it serves.



Dan Paulo E. Amado is pursuing a Bachelor's Degree in Computer Engineering at De La Salle University-Manila. Her role in the group is to run quality checks. With her keen sight for details, she provides constructive criticisms as to where the group will set rooms for further improvements and necessary corrections from established ideas.



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